IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

CYWEE GROUP LTD., ***Plaintiff,*** **SAMSUNG ELECTRONICS CO., LTD. AND SAMSUNG ELECTRONICS AMERICA, INC.** ***Defendants.***	**CASE NO. 2:17-cv-00140-RWS-RSP** **JURY TRIAL DEMANDED**

DECLARATION OF JOSEPH J. LAVIOLA, JR., PH.D. IN SUPPORT OF CYWEE GROUP LTD'S REPLY CLAIM CONSTRUCTION BRIEF

I hereby declare as follows:

1. The following opinions supplement those in my prior declaration signed February 23, 2018. (Dkt. 66-6).

2. In preparing this declaration I have reviewed—in addition to the materials listed and/or cited in my prior declaration (Dkt. 66-6 ¶ 2)—the following materials: Defendants' Responsive Claim Construction Brief (Dkt. 67) and accompanying exhibits, the declaration testimony of Dr. M. Ray Mercer (Dkt. 67-1), and any additional materials cited herein.

I. SUPPLEMENTATION REGARDING EXPERIENCE AND QUALIFICATIONS

3. I want to supplement my expertise in estimation theory, including optimal estimators such as Kalman and Extended Kalman filters (EKFs) and their variations. I have been working with dynamic estimators, including EKFs, for over 15 years. I have implemented EKFs in practice and written several papers on EKFs as part of my work in motion tracking and 3D interfaces, including the following:

Julier, S., and LaViola, J. "On Kalman Filtering with Nonlinear Equality Constraints", *IEEE Transactions on Signal Processing*, 55(6):2774-2784, June 2007.

LaViola, J. "A Comparison of Unscented and Extended Kalman Filtering for Estimating Quaternion Motion", In the *Proceedings of the 2003 American Control Conference*, IEEE Press, 2435-2440, June 2003.

LaViola, J. "Double Exponential Smoothing: An Alternative to Kalman Filter-Based Predictive Tracking", In the *Proceedings of Immersive Projection Technology and Virtual Environments 2003*, ACM Press, 199-206, May 2003.

4. I have also been teaching EKFs to my students over the last 15 years. An example of work using EKFs that I published with one of my students follows:

Williamson, B., and Wingrave, C., and LaViola, J. "RealNav: Exploring Natural User Interfaces for Locomotion in Video Games", *Proceedings of the IEEE Symposium on 3D User Interfaces 2010*, 3-10, March 2010.

5. These papers clearly demonstrate my expertise and foundational understanding of EKFs in terms of the mathematical equations and formulae, as well as related implementation strategies and challenges.

II. SUPPLEMENTAL OPINION ON PERSON OF ORDINARY SKILL IN THE ART

6. In addition to the qualifications described in my previous declaration (Dkt. 66-6 ¶ 11), it is my opinion that a person of ordinary skill in the art would be familiar with Kalman filters and extended Kalman filters, and equations typically used with such filters.

III. SUPPLEMENTAL OPINIONS REGARDING TERMS ALLEGED INDEFINITE BY SAMSUNG

A. "utilizing a comparison to compare the first signal set with the second signal set" ('438 patent claim 1)

7. The '438 and '978 patents disclose, to a person of ordinary skill in the art, a

method for dynamic estimation of the orientation of a moving object. Kalman filters and EKFs are quintessential recursive estimators (meaning they update existing estimates based on new measurements). They are optimal estimators under certain conditions and have been proven reliable and accurate in many fields. There are a variety of implementations and modifications that can be made to EKFs for various applications. Nevertheless, they all share a fundamental underlying structure, methodology and mathematical theory that a person of ordinary skill in the art would recognize. For simplicity, I will refer to this class of recursive estimators as EKFs going forward.

8. Samsung relies on Dr. Mercer's testimony for the premise that a person of ordinary skill in the art would not recognize the patents to disclose an estimator incorporating elements of an EKF. But Dr. Mercer has never written a paper on Kalman filters (Ex. A[1] 29:5-8), has no patents on Kalman filters (Ex. A 29:21-30:4), has never implemented an extended Kalman filter or EKF (Ex. A 31:4-7), and is not familiar with fundamental equations underlying an EKF (Ex. A 151:13-21; 166:6-25).

9. Specifically, Dr. Mercer was questioned during his deposition about two references on an EKF. The first is a Wikipedia article on Extended Kalman Filters, which is attached to Plaintiff's reply brief as Exhibit 7 to Exhibit A.[2] The second is an article cited by the Wikipedia article, entitled "Optimal State Estimation." That article is attached to Plaintiff's reply brief as Exhibit 8 to Exhibit A. Dr. Mercer was not familiar with the equations in either article. Ex. A 151:13-21; 166:6-25. Dr. Mercer also testified that the equations from these papers were not equivalent to those of the patents-in-suit. *Id.* 152:6-163:8, 167:15-167:25, 169:21-174:15. I

[1] Unless referenced by docket number, exhibits referenced herein are being submitted concurrently with CyWee's Reply Claim Construction Brief.
[2] Exhibit A is the transcript of Dr. Mercer's deposition along with selected exhibits from that deposition.

disagree with Dr. Mercer on this point.

10. It is important to note that the EKF can be described mathematically in a number of ways depending on different mathematical notational styles (e.g., probabilistic, Matrix-Vector notation, time series), as well as depending on the discipline (e.g., computer science, electrical engineering, control theory, signal processing). Regardless of how the equations are presented, anyone of ordinary skill in the art would understand the fundamental meaning of the equations and would be able to identify their meaning regardless of how the equations are represented. For the purposes of my declaration, I will use the term “equivalent” to mean an equivalent representation rather than strict term by term mathematical equivalence.

11. One can clearly see the similarities between the equations that describe components of an embodiment of the “enhanced comparison method” in the ’438 and ’978 patents and the equations that describe the EKF equations found in Exhibit 7 from Dr. Mercer’s deposition. In that exhibit, the predicted state estimate is equivalent to Equation 5 in the ’438 and ’978 patents. The predicted covariance estimate is equivalent to the Equation above Equation 6 in the ’438 and ’978 patents. The state transition Jacobian matrix is equivalent to Equations 6 and 7 in the ’438 and ’978 patents. This state transition Jacobian matrix in this exhibit maps to both Equations 6 and 7 based on which variable is held constant during partial differentiation. Equation 8 describes the innovation or measured residual, which is defined in this exhibit and named as such. The innovation or measured residual covariance matrix is equivalent to Equation 9 in the ’438 and ’978 patents. The observation Jacobian matrix described in this exhibit is equivalent to Equation 10 in the ’438 and ’978 patents.

12. Similarly, one can clearly see the similarities between the equations that describe the “enhanced comparison method” in the ’438 and ’978 patents and the equations that describe

the EKF equations found in Exhibit 8 from Dr. Mercer's deposition. The first equation listed in that exhibit is equivalent to Equation 5 in the '438 and '978 patents while the second equation listed in that exhibit is equivalent to Equation 8 in the '438 and '978 patents. Equations marked in that exhibit as group (13.46) are equivalent to Equations 6 and 7 respectively in the '438 and '978 patents. The first equation in group (13.47) in that exhibit is equivalent to the Equation above Equation 6 in the '438 and '978 patents. The first equation in group (13.48) in that exhibit is equivalent to Equation 10 in the '438 and '978 patents. Finally, the first equation in group (13.49) in that exhibit is equivalent to Equation 9 in the '438 and '978 patents.

13. Given these mathematical similarities, any person of ordinary skill in the art would understand that the "enhanced comparison method" disclosed in the '438 and '978 patents represent an estimator that includes components of an EKF or close variation thereof. Since Dr. Mercer did not recognize the equations in Exhibits 7 and 8 from his deposition, has never implemented an EKF and has no papers or patents on the EKF, he cannot be considered an expert in this area and cannot make the claim these equations do not describe an EKF. Given my expertise with EKFs, the equations (5-11) in the '438 and '978 patents do indeed describe an EKF that provides a basis for the enhanced comparison method.

14. Dr. Mercer's main argument against the claim term "utilizing a comparison to compare the first signal set with the second signal set" continues to be the fact that there are multiple sources of acceleration that an accelerometer can measure including gravitational, linear, and centrifugal accelerations and that a person of ordinary skill in the art would not know how to separate these accelerations, making the accelerometer measurements ambiguous. He further argues that this lack of distinction among accelerations would make it impossible to compare angular velocity with data from the accelerometers and deal with motions caused by

rigid vs. non-rigid bodies.

15. The ’438 and ’978 patents plainly state that an accelerometer is subject to multiple sources of acceleration, thus justifying the need for an “enhanced comparison method” that can handle the measurement errors that stem from these different sources as well as other disturbances and noise. ’438 patent 4:65-5:8; ’978 patent 5:38-45. Since Dr. Mercer does not have sufficient expertise to understand estimators such as the EKF, he continues to opine that the different types of acceleration make the claim term indefinite, which is simply not the case. A person of ordinary skill would understand that the methods described in the patents are designed to handle different types of acceleration. An EKF or similar estimator can be designed to handle such differences, and a person of ordinary skill in the art would understand that. The enhanced comparison method described in the patent handles these errors to provide an optimal estimate for the deviation angles of the 3D pointing device.

16. Dr. Mercer does not dispute that the 3D pointing device itself is a rigid body but instead argues that bodies acting on the 3D pointing device could be considered non-rigid and would introduce accelerations other than gravitational acceleration including linear and centrifugal accelerations which would cause ambiguities. Once again, Dr. Mercer misses the point by not understanding that the patent discloses an enhanced estimator designed to handle these differences and any person of ordinary skill in the art would understand this concept. Thus, a non-rigid body acting on the 3D pointing device would not make any difference in the computation of the deviation angles of the 3D pointing device when using the “enhanced comparison method.”

17. Given these arguments, Dr. Mercer’s assertions are incorrect because he does not have the expertise to know what a person of ordinary skill in the art would or would not know in

relation to EKFs because he himself does not have the expertise to know how the EKF is taught as part of an "enhanced comparison method in the '438 and '978 patents. Furthermore, a person of ordinary skill in the art would recognize that components of an EKF can be employed as stages or bases of a novel estimator suitable for specific problems or sensor types.

18. Samsung incorrectly presumes that, if the patent discloses an EKF, it is invalid. This is incorrect because the claims at issue have specific requirements that must be met, regardless of whether an EKF or variant thereof is used. As I testified during my deposition, an EKF is a general framework, and there are different ways to construct and initialize the filter.

19. It is my opinion that a person of ordinary skill in the art, coupled with the disclosures regarding the "enhanced comparison method" described in the '438 and '978 patents, would understand the meaning of the claim term, "utilizing a comparison to compare the first signal set with the second signal set" with reasonable certainty, making it not indefinite.

B. "comparing the second quaternion in relation to the measured angular velocities ωx, ωy, ωz of the current state at current time T with the measured axial accelerations Ax, Ay, Az and the predicted axial accelerations Ax´, Ay´, Az´ also at current time T" ('438 patent claims 14, 19)

20. My opinions presented in § 3.A of this declaration hold for this claim term in regards to Dr. Mercer's arguments for indefiniteness in his original and revised declarations.

21. For this term, Dr. Mercer also argues that the predicted axial accelerations are ambiguous, and they could contain a combination of linear, gravitational, and centrifugal acceleration components that would not be distinguishable to a person of ordinary skill in the art.

22. My arguments against Dr. Mercer's claims described in § 3.A also hold for predicted axial accelerations.

23. In addition, Dr. Mercer fails to recognize that for the case of predicted axial accelerations described in the '438 and '978 patents, Equations 2-4 provide in the '438 and '978

patents an embodiment having a predicted axial acceleration, which is derived from the second quaternion that is computed from Equation 1, and this quaternion is derived from the first quaternion and the measured angular velocities (see Figures 7 and 8 in both patents). Since the predicted axial acceleration is derived from the second quaternion, and a person of ordinary skill in the art would understand that the second quaternion is normalized so that it represents orientation, then the predicted axial accelerations would represent and only represent axial accelerations that would stem from gravity (since gravitational acceleration is used to determine orientation). There would be no linear or centrifugal acceleration components as part of the predicted axial acceleration. Thus, Dr. Mercer's claim regarding the predicted axial accelerations is false, and even if it was true it still would not make any difference because the "enhanced comparison method" would deal with different types of acceleration regardless.

C. "generating the orientation output based on the first signal set, the second signal set and the rotation output or based on the first signal set and the second signal set" ('978 patent claim 10)

24. Dr. Mercer also makes his axial acceleration ambiguity argument for this claim term, and my opinions presented in § 3.A of this declaration hold for this claim term in regards to Dr. Mercer's arguments for indefiniteness in his original and revised declarations. Dr. Mercer argues that my opinion regarding the use of the "enhanced comparison method" to determine deviation angles of the 3D pointing device using axial accelerations and magnetometer readings when the device is moving is not possible given the nature of what an estimator such as an EKF can and cannot do in terms of noise and measurement error.

25. As stated in paragraphs 7 and 8, it is clear that Dr. Mercer does not understand the fundamental issues and mathematics behind the EKF and its variants. If he did, he would know that the EKF is part of a method designed to handle errors or differences in axial accelerations and noise from the magnetometer, and that a person of ordinary skill in the art would be able to

look at the equations (5-11) that describe the "enhanced comparison method" in the '978 patent and be able to use the "enhanced comparison method" to compute the deviation angles of the 3D pointing device when using the axial accelerations and magnetometer information when the 3D pointing device is moving.

26. To be more specific, as I stated in my deposition, the EKF is a framework, and there are many different ways that such a filter can be constructed and initialized. The foundational equations in the EKF, and equivalently Equations (5-11) in the '978 patent, are written in such a way that they are general. As I discussed in my previous declaration, the EKF is a set of mathematical equations that uses an underlying process model to estimate the current state of a system and then corrects the estimate using any available sensor measurements using a measurement model. Using this predictor-corrector mechanism, it approximates an optimal estimate due to the linearization of the process and measurement models.

27. The process and measurement models are what make an EKF specific for a particular estimate. For example, the '978 patent presents one embodiment that uses angular velocities in the process model and predicted and measured axial accelerations in the measurement model. Regardless of what is used in the process and measurement models, Equations (5-11), describing an embodiment of the "enhanced comparison method" in the '978 patent, may be used. One can get deviation angles of the 3D pointing device using different process models and using different sensors depending on how the filter is constructed and initialized, through the process and measurement models. Any person of ordinary skill in the art would understand this concept, as it is fundamental to the EKF and its variants.

28. In the '978 patent, to obtain deviation angles of the 3D pointing device when it is moving by using accelerometers and magnetometers, a person of ordinary skill in the art would

use Equations (5-11) as a blueprint for the "enhanced comparison method" and construct the process and measurement models using the acceleration and magnetometer sensors. This filter is considered to be another embodiment of the "enhanced comparison method." This is clearly stated in the '978 patent: "In one example, external forces exerted to cause axial accelerations of a nine-axis motion sensor of an electronic device of the present invention may be decoupled or separated from a force of gravity; and in another example, the undesirable magnetism caused by such as electromagnetic fields external or internal to an electronic device the present invention may be excluded. It can be understood that the examples of current state, measured state, state update, data association and probabilities of the comparison model and method of the present invention recited herein are provided for illustrative purposes only." '978 patent 18:44-55. The "enhanced comparison method" blueprint, described in Equations (5-11), provide for this flexibility. Thus, Dr. Mercer's arguments are not valid, and the term is not indefinite.

IV. SUPPLEMENTAL OPINIONS REGARDING ADDITIONAL TERMS

A. "six-axis motion sensor"/"six axis motion sensor module" ('438 patent claims 1, 3, 4, 5, 14, 15, 16, 17, 19)

29. I have reviewed Exhibit 8 (Dkt. 67-13) to Samsung's Responsive Claim Construction Brief, wherein the Applicant responded to the directive to maintain a "clear line of demarcation" between the '438 patent and the '978 patent. The Applicant's response indicates that the subject matter of the '978 Patent is differentiated by the fact that it requires a nine-axis motion sensor including a magnetometer with a measured output. In my opinion, this simply means that the '978 Patent requires a magnetometer with a measured output, whereas the '438 Patent contains no such requirement. This is confirmed by the patent's repeated use of the term "comprising" in claim 10.

B. "global reference frame associated with Earth" ('978 patent claim 10)

30. The term "global reference frame" or "global frame of reference" is a commonly used term in the art, which refers to a fixed frame, against which the position and orientation of moving frames can be measured. A person of ordinary skill in the art would understand that there are many valid "global reference frames" and would further understand that, while an example of global reference is an Earth-centered frame, that is ***not the only type*** of global reference frame. Similarly, a person of ordinary skill in the art would not read the term "global reference frame associated with the Earth" as being limited solely to a reference frame with an axis at or near the center of the Earth.

31. Samsung cites a textbook for the premise that "'Earth frames' are used 'when the user wants to know their position relative to the Earth.'" For clarification, the quotation Samsung refers to discusses an "Earth-Centered Earth-Fixed Frame" and states that such an "Earth frame is important in navigation because the user wants to know their position relative to the Earth, so it is commonly used as both a reference frame and a resolving frame." Dkt. 67-15 § 2.1.2. Samsung's citation does not demonstrate that the global reference frame associated with Earth should be construed as it proposes. There is no requirement in the patent that it is limited to navigation, and, even if it were, Samsung's reference also discloses a local navigation frame, which may also be used, which does not have its origin at the center of the Earth. *Id.* § 2.1.3. For example, Samsung's reference discloses a "local navigation frame" in which one axis points "roughly toward the center of the Earth" but the origin is not at or near the center of the Earth. The '978 patent repeatedly states that the global reference frame is "associated with the Earth." *See* '978 patent Claim 10, Abstract ("The orientation sensor generates an orientation output . . . associated with three coordinate axes of a global reference frame associated with the Earth"), Fig. 13 Step 1320 ("Generate an orientation output associated with the 3D pointing device

associated with Earth), 8:5-6. This includes ***both*** reference frames with an origin at or near the center of the Earth, as well as reference frames with an origin elsewhere, such as a specific location at or near the surface of the Earth.

32. CyWee's construction does not eliminate the term "global" as alleged by Samsung simply because it allows for an origin occurring at or near different locations of the globe. There is no indication in the patent that it is so-limited, and my review of materials cited by both CyWee and Samsung confirms my opinion.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge and understanding, and further testify that statements made in my prior declaration (Dkt. 66-6) are true and correct to the best of my knowledge and understanding.

March 21, 2018
Date

Joseph J. LaViola, Jr., Ph.D